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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

January 12, 1994

BY HAND DELIVERY

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, N.W., Room 222
Washington, D.C. 20554

Re: EX PARTE PRESENTATION
Proposed Allocation of Spectrum in the 27.5 to 29.5 GHz band to Local Multipoint Distribution Service, CC Docket No. 92-297

Dear Mr. Caton:

Enclosed on behalf of Hughes Space and Communications Company ("HSC") is an ex parte presentation in the matter referenced above that addresses HSC's concerns about the technical compatibility of LMDS and satellite services. This letter and the accompanying presentation are being filed at 9:00 a.m. today.

Sincerely yours,

John P. Janka

Enclosure

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Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, N.W., Room 222
Washington, D.C. 20554

Re: Proposed Allocation of Spectrum in the 27.5 to 29.5 GHz band to Local Multipoint Distribution Service, CC Docket No. 92-297

Dear Mr. Caton:

This letter reiterates the concerns of Hughes Space and Communications Company ("HSC") that any action the Commission may take with respect to allocating spectrum in the 27.5 to 29.5 GHz band to a Local Multipoint Distribution Service ("LMDS") should be consistent with proposed and future uses of that band for satellite communications.

HSC's fundamental concern is that satellite earth stations in the band proposed for LMDS are likely to cause objectionable interference into LMDS receivers. Thus, it is essential to resolve the incompatibility of LMDS and satellite services at this point, rather than addressing interference issues once the two services begin to develop in the same band.

Specifically, HSC requests that the Commission either (i) defer action on this item to allow interested parties to determine whether satellite and LMDS users can coexist at Ka band and to address the use of alternative frequency bands for LMDS, or (ii) institute a proceeding that requires LMDS proponents and satellite interests to negotiate these issues under the oversight of the Commission.

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OFFICE OF THE SECRETARY

A. Introduction

HSC is a leading provider of communications satellites in the fixed satellite service ("FSS") bands, both C band (6/4 GHz) and Ku band (14/11 GHz). HSC's affiliate, Hughes Communications Galaxy, Inc. ("HCG") is the largest operator of commercial communications satellites in the United States: it has ten FSS satellites and one DBS satellite in orbit and has plans to launch three more satellites in the near future.

HSC and its affiliates have been exploring for some time the possible uses of the Ka band (27.5 to 30.0 GHz), which has been set aside as an expansion band for commercial communications satellites. On December 3, 1993, HCG filed an application for a two-satellite system, to be known as "Spaceway," that would operate in a portion of this band. HCG's proposed system would essentially be a space-based telecommunications superhighway. It would offer a wide range of universal, high data-rate, bandwidth-on-demand services, complement the proposed National Information Infrastructure (NII), and help to meet the needs of those who will not be physically connected to the terrestrial NII.

B. Satellite Interference Into LMDS is the Key Issue

The fundamental issue that has not been resolved in this proceeding is whether satellite users and LMDS users can share the 27.5-29.5 GHz band in the same geographic area. HSC and its affiliates have consistently expressed concern that the Commission's accommodation of LMDS not render the Ka band unusable to satellite operators. HSC's views have been echoed by many others in the industry, including NASA, Motorola, Loral Qualcomm Satellite Services, Calling Communications and Norris Satellite Communications.

Attached as Exhibit 1 is an analysis prepared by HSC engineers that demonstrates that there is a significant potential for harmful interference into LMDS receivers from satellite earth stations.

This analysis uses publicly available data about the proposed Suite 12 system and propagation model, as well as information about HCG's proposed Spaceway system. In the Spaceway system, HSC anticipates a large-scale, mass-market deployment of ultra small earth stations to countless business and residential end users. As LMDS will likely be marketed to similar end users, it would not be unlikely to find neighboring installations of Spaceway earth stations and LMDS receivers that would present the interference potential described in Exhibit 1. The attached analysis is illustrative of the interference problems that will affect not only the proposed Spaceway system, but also the future use of the Ka band in general.

Although two of the petitioners in this proceeding, Suite 12 Group and Video/Phone Systems, have argued in recent ex parte presentations that their proposed LMDS systems are compatible with satellite use of the Ka band, it simply is premature to conclude now that LMDS is compatible with satellite services. Specifically, LMDS proponents have failed to adequately assess the potential for interference from satellite earth stations into LMDS, as demonstrated in Exhibit 1. If LMDS proponents are wrong, it is the satellite industry, not LMDS, that would bear the risk.

Authorizing LMDS to operate at 27.5 to 29.5 GHz would put the satellite industry at risk of being relegated to secondary status once LMDS becomes operational. Satellite services currently are co-primary with terrestrial services at 27.5 to 29.5 GHz. However, if LMDS is authorized, it appears that LMDS service would likely commence before commercial satellite service in this band. Thus, as a co-primary but second-in-time user, if a satellite service caused interference into a pre-existing LMDS service, the satellite service could be required to cease operations, as coordination would not likely be possible.

The ultimate impact on the satellite industry would be devastating. Satellite operators could find that over 80% of the uplink expansion band now available for fixed satellite service ultimately would not be available to them. Moreover, the loss of this 2000 MHz of expansion uplink band would effectively result in the loss of the companion expansion downlink band at 17.7 to 19.7 GHz. The possible loss of such a significant amount of expansion frequencies makes it imperative that LMDS and satellite interference issues be fully analyzed.

In order to better understand the technical nature of the proposed LMDS systems, HSC has recently met with representatives of the Suite 12 Group. We are engaged in a continuing dialogue with Suite 12. We also have attempted to arrange a meeting with Video/Phone, but that meeting will not likely occur until Video/Phone provides additional information to HSC. HSC's discussions to date with LMDS proponents have been helpful, but have not resolved HSC's concerns.

Even assuming that there are circumstances where LMDS receivers can coexist with satellite uplinks, LMDS proponents and satellite interests have not even begun to address what types of spectrum sharing criteria are appropriate to preserve the co-primary status of satellite services. As set forth above, simply concluding that LMDS can coexist with satellites raises the prospect of unintentionally relegating satellite services to secondary status. At a minimum, if the Commission determines that spectrum sharing is possible, it is imperative that appropriate sharing criteria be established. This issue simply has not yet been addressed.

Having recognized the potential for objectionable interference, HSC and other parties to this proceeding have suggested that the Commission accommodate LMDS in other frequency bands where these conflicts will not exist, such as 36-40 GHz or 40.5-42.5 GHz. Sixteen European nations have endorsed a plan to accommodate LMDS-type services at 40.5 to 42.5 GHz. Thus, an opportunity may exist to implement LMDS at those frequencies. This alternative deserves serious consideration because it would not only solve a potential interference problem, but also would ensure that the U.S. frequency table is harmonious with European plans and allow U.S. LMDS equipment manufacturers access to foreign markets.

C. Conclusion

HSC appreciates the concerns of the LMDS proponents that the Commission act promptly on this matter. That action should not, however, be taken without due consideration for future uses of the Ka band for satellite service. As the Commission is aware, over the past six weeks (and as late as last Wednesday), the LMDS proponents have filed volumes of ex parte papers that address many significant new issues that impact the satellite industry and warrant careful further consideration.

Therefore, HSC urges the Commission to either (i) defer action on this item to allow interested parties to determine whether satellite and LMDS users can coexist at Ka band and to address the use of alternative frequency bands for LMDS, or (ii) institute a proceeding that requires LMDS and satellite proponents to negotiate these issues under the oversight of the Commission.

HSC has no objection to the generic concept of LMDS. However, the 2.5 GHz of bandwidth currently available at Ka band for expansion of FSS service presents a unique opportunity for satellite services to complement and compete with the proposed terrestrial NII. Action in this docket should not forestall that opportunity.

Respectfully submitted,

HUGHES SPACE AND COMMUNICATIONS COMPANY,
a unit of Hughes Aircraft Company

By:____________________
John P. Janka
Its Counsel

cc: Chairman Reed E. Hundt
Commissioner James H. Quello
Commissioner Andrew C. Barrett
Commissioner Ervin S. Duggan
Ms. Karen Brinkmann
Mr. Randy Coleman
Mr. Brian F. Fontes
Mr. Bruce A. Franca
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Mr. James R. Keegan
Ms. Susan E. Magnotti
Mr. Byron F. Marchant
Mr. Harold Ng
Mr. Thomas P. Stanley
Mr. Thomas S. Tycz

SPACEWAY VSAT Interference into LMDS Receiver

Introduction

The Local Multipoint Distribution System (LMDS) is a terrestrial wireless video distribution service in a multicell configuration proposed for operation in the 27.5 to 29.5 GHz band. Within each cell, 1 GHz is used to transmit up to 49 analog FM video channels.

An FSS VSAT operating in the vicinity of an LMDS subscriber terminal may pose unacceptable interference levels to LMDS. This report analyses the interference condition from a SPACEWAY VSAT to an LMDS receiver.

Methodology

LMDS baseline characteristics contained in Suite 12 Group's Petition for Rulemaking dated September 23, 1991 were used to develop a link model patterned after the Suite 12 Group analysis. This model uses the same rain model given in Suite 12 Group's petition (1982 CCIR) and replicates the results of Suite 12 Group's analysis. From this model, the LMDS carrier power was compared to the SPACEWAY interference power as a function of antenna off-axis angle to determine the required minimum separation distance between the SPACEWAY VSAT and the LMDS receiver. CCIR recommendations were used to model the antenna patterns. In particular, the SPACEWAY VSAT antenna was modeled after Radio Regulation Appendix 29 Annex III with d/lambda < 100 (FSS) and the LMDS receive antenna model is from Radio Regulation Appendix 30 Figure 8 (BSS). These internationally accepted models are reasonable assumptions in lieu of extensive antenna performance data. The minimum acceptable single entry C/I is assumed to be 25 dB.

Six cases were considered in this analysis: three LMDS subscriber dish sizes, each in the presence and absence of rain (New York). The LMDS receive antenna is assumed to be at the cell edge, which is sized to provide a rain-faded C/N of 13.5 dB. The results indicate that under the best of conditions (clear sky, backlobe to backlobe) the minimum separation distance is several hundred feet. In more severe conditions, the minimum separation distance quickly increases.

LMDS Link Model

The following link equation is the basis for this analysis:

$$CNR = P - BO - 10\log(n) - La + Gt + Ls + Gr - k - Ts - BW - A$$

where:

- CNR = rain faded carrier-to-noise ratio, dB
- P = amplifier output power, dBW
- BO = amplifier output backoff, dB
- n = number of channels
- La = loss to antenna input, dB
- Gt = transmit antenna gain, dB

Ls = free space loss = 20log(lambda/4πR)
lambda = 0.3/freq(GHz)
R = range (m) = D*(1609 m/mile)
D = cell radius (mile)
Gr = receive antenna gain = 10log(πr^2*55%*4π/lambda^2)
r = dish radius (m) = d/2*(0.0254 m/in)
d = dish diameter (inch)
k = Boltzman's constant = -228.6 dBW/Hz•K
Ts = receive system noise temperature, dBK
BW = bandwidth, dBHz

The last term, A, is the attenuation due to rain based on the 1982 CCIR rain model:

A = rain attenuation for $0.01 < p \leq 0.1$
= a(R(0.01%)^b)*l*(90/(90+4*l))*(p/0.01)^(-0.41)
R(0.01%) = rain rate exceeded for 0.01% of average year,
= 30 mm/hr (Los Angeles), 52.4 mm/hr (New York)
a and b are frequency dependent:
28 GHz: a = 0.162, b = 1.037
l = path length (km) = D*(1.609 km/mile)
p = unavailability (%) = 0.1 (99.9% availability)

Results

Tables 1 through 6 show the LMDS link and SPACEWAY interference level for 3 subscriber dish sizes, 4.5, 7.5 and 15 inches for clear sky and rain conditions. In these tables, the LMDS and SPACEWAY antennas are assumed to be in the lowest interference condition, i.e., backlobe to backlobe. The tables show that the minimum required separation distance for these six cases vary between 235 and 2425 feet. Given that SPACEWAY VSATs and LMDS receivers could be co-located in the same household or be located in adjacent buildings, these required separation distances are unacceptable. Figures 1 through 6 expand on the calculations presented in the tables to show the increase in separation distance as the relative angle between the two antennas decreases. In each figure, several separation distances are plotted as a function of the off-axis angle of both the LMDS and SPACEWAY antennas. For typical pointing angles, the separation distances are on the order of thousands of feet.

Conclusions

SPACEWAY and LMDS do not appear to be compatible due to unacceptable interference from SPACEWAY user terminals to LMDS subscriber receivers. Similar interference problems might also arise with future FSS applications based on ACTS technology. The 28 GHz band is ideally suited for the evolving high bit rate services using small antennas which are commercially available on a large scale. No other band is suitable for these applications.

Prepared by R. LeClair
Hughes Space and Communications
January 11, 1994

Table 1 - SPACEWAY VSAT Interference into LMDS Receivers

1/11/94

Frequency, GHz	28.0	Rain rate for 0.01%, mm/hr	0.0
Lambda, m	0.011	Rain model constants: alpha	0.162
		beta	1.037

LMDS Carrier		SPACEWAY Interference	
Output power per channel, dBW/channel	-4.0	Output power per channel, dBW/channel	-3.5
Channel Bandwidth, MHz	18.0	Channel Bandwidth, MHz	0.5
Transmitting antenna feed loss, dB	1.0	Transmit antenna diameter, m	0.66
Transmitting antenna gain, dBi	10.0	Transmit peak gain, dB	43.1
		Angle toward LMDS receiver, degrees	180
Distance to subscriber, miles	2.4	Gain in direction of LMDS receiver, dB	-7.9
Free space loss, dB	-133.1		
		Distance to LMDS receiver, ft	235
Subscriber dish diameter, inches	4.5	Free space loss, dB	-98.5
Receiver antenna gain, dBi	27.9		
		LMDS receive antenna diameter, inches	4.5
Boltzman's constant, dBW/Hz•K	-228.6	LMDS receive peak gain, dB	27.9
Receiver noise temperature, dBK	29.5	Half power beamwidth, degrees	6.6
Bandwidth, dBHz	72.6	LMDS off-axis angle, degrees	180
		Relative angle (angle/beamwidth)	27.2
Carrier-to-noise ratio, dB	26.3	Relative antenna gain (App 30 Fig 8)	-43.2
		LMDS receiver gain, dB	-15.3
Rain attenuation (99.9% availability), dB	0.0		
		Rain attenuation (99.9% availability), dB	0.0
Rain faded carrier power, dBW	-100.2		
Noise power, dBW	-126.5	Interference power, dBW	-125.2
Rain faded carrier-to-noise ratio, dB	26.3	LMDS carrier power, dBW	-100.2
		Interference power, dBW	-125.2
		C/I, dB	25.0
		Required C/I, dB	25.0

Table 2 - SPACEWAY VSAT Interference into LMDS Receivers

1/11/94

Frequency, GHz	28.0	Rain rate for 0.01%, mm/hr	52.4
Lambda, m	0.011	Rain model constants: alpha	0.162
		beta	1.037

LMDS Carrier		SPACEWAY Interference	
Output power per channel, dBW/channel	-4.0	Output power per channel, dBW/channel	-3.5
Channel Bandwidth, MHz	18.0	Channel Bandwidth, MHz	0.5
Transmitting antenna feed loss, dB	1.0	Transmit antenna diameter, m	0.66
Transmitting antenna gain, dBi	10.0	Transmit peak gain, dB	43.1
		Angle toward LMDS receiver, degrees	180
Distance to subscriber, miles	2.4	Gain in direction of LMDS receiver, dB	-7.9
Free space loss, dB	-133.1		
		Distance to LMDS receiver, ft	890
Subscriber dish diameter, inches	4.5	Free space loss, dB	-110.1
Receiver antenna gain, dBi	27.9		
		LMDS receive antenna diameter, inches	4.5
Boltzman's constant, dBW/Hz-K	-228.6	LMDS receive peak gain, dB	27.9
Receiver noise temperature, dBK	29.5	Half power beamwidth, degrees	6.6
Bandwidth, dBHz	72.6	LMDS off-axis angle, degrees	180
		Relative angle (angle/beamwidth)	27.2
Carrier-to-noise ratio, dB	26.3	Relative antenna gain (App 30 Fig 8)	-43.2
		LMDS receiver gain, dB	-15.3
Rain attenuation (99.9% availability), dB	12.6		
		Rain attenuation (99.9% availability), dB	1.0
Rain faded carrier power, dBW	-112.8		
Noise power, dBW	-126.5	Interference power, dBW	-137.8
Rain faded carrier-to-noise ratio, dB	13.7	LMDS carrier power, dBW	-112.8
		Interference power, dBW	-137.8
		C/I, dB	25.0
		Required C/I, dB	25.0

Table 3 - SPACEWAY VSAT Interference into LMDS Receivers

1/11/94

Frequency, GHz	28.0	Rain rate for 0.01%, mm/hr	0.0
Lambda, m	0.011	Rain model constants: alpha	0.162
		beta	1.037

LMDS Carrier		SPACEWAY Interference	
Output power per channel, dBW/channel	-4.0	Output power per channel, dBW/channel	-3.5
Channel Bandwidth, MHz	18.0	Channel Bandwidth, MHz	0.5
Transmitting antenna feed loss, dB	1.0	Transmit antenna diameter, m	0.66
Transmitting antenna gain, dBi	10.0	Transmit peak gain, dB	43.1
		Angle toward LMDS receiver, degrees	180
Distance to subscriber, miles	3.0	Gain in direction of LMDS receiver, dB	-7.9
Free space loss, dB	-135.1		
		Distance to LMDS receiver, ft	415
Subscriber dish diameter, inches	7.5	Free space loss, dB	-103.4
Receiver antenna gain, dBi	32.3		
		LMDS receive antenna diameter, inches	7.5
Boltzman's constant, dBW/Hz*K	-228.6	LMDS receive peak gain, dB	32.3
Receiver noise temperature, dBK	29.5	Half power beamwidth, degrees	4.0
Bandwidth, dBHz	72.6	LMDS off-axis angle, degrees	180
		Relative angle (angle/beamwidth)	45.4
Carrier-to-noise ratio, dB	28.8	Relative antenna gain (App 30 Fig 8)	-40.2
		LMDS receiver gain, dB	-7.9
Rain attenuation (99.9% availability), dB	0.0		
		Rain attenuation (99.9% availability), dB	0.0
Rain faded carrier power, dBW	-97.7		
Noise power, dBW	-126.5	Interference power, dBW	-122.7
Rain faded carrier-to-noise ratio, dB	28.8	LMDS carrier power, dBW	-97.7
		Interference power, dBW	-122.7
		C/I, dB	25.0
		Required C/I, dB	25.0

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Table 4 - SPACEWAY VSAT Interference into LMDS Receivers

1/11/94

Frequency, GHz	28.0	Rain rate for 0.01%, mm/hr	52.4
Lambda, m	0.011	Rain model constants: alpha	0.162
		beta	1.037

LMDS Carrier		SPACEWAY Interference	
Output power per channel, dBW/channel	-4.0	Output power per channel, dBW/channel	-3.5
Channel Bandwidth, MHz	18.0	Channel Bandwidth, MHz	0.5
Transmitting antenna feed loss, dB	1.0	Transmit antenna diameter, m	0.66
Transmitting antenna gain, dBi	10.0	Transmit peak gain, dB	43.1
		Angle toward LMDS receiver, degrees	180
Distance to subscriber, miles	3.0	Gain in direction of LMDS receiver, dB	-7.9
Free space loss, dB	-135.1		
		Distance to LMDS receiver, ft	1875
Subscriber dish diameter, inches	7.5	Free space loss, dB	-116.5
Receiver antenna gain, dBi	32.3		
		LMDS receive antenna diameter, inches	7.5
Boltzman's constant, dBW/Hz•K	-228.6	LMDS receive peak gain, dB	32.3
Receiver noise temperature, dBK	29.5	Half power beamwidth, degrees	4.0
Bandwidth, dBHz	72.6	LMDS off-axis angle, degrees	180
		Relative angle (angle/beamwidth)	45.4
Carrier-to-noise ratio, dB	28.8	Relative antenna gain (App 30 Fig 8)	-40.2
		LMDS receiver gain, dB	-7.9
Rain attenuation (99.9% availability), dB	15.2		
		Rain attenuation (99.9% availability), dB	2.1
Rain faded carrier power, dBW	-112.9		
Noise power, dBW	-126.5	Interference power, dBW	-137.9
Rain faded carrier-to-noise ratio, dB	13.7	LMDS carrier power, dBW	-112.9
		Interference power, dBW	-137.9
		C/I, dB	25.0
		Required C/I, dB	25.0

Table 5 - SPACEWAY VSAT Interference into LMDS Receivers

1/11/94

Frequency, GHz	28.0	Rain rate for 0.01%, mm/hr	0.0
Lambda, m	0.011	Rain model constants: alpha	0.162
		beta	1.037

LMDS Carrier		SPACEWAY Interference	
Output power per channel, dBW/channel	-4.0	Output power per channel, dBW/channel	-3.5
Channel Bandwidth, MHz	18.0	Channel Bandwidth, MHz	0.5
Transmitting antenna feed loss, dB	1.0	Transmit antenna diameter, m	0.66
Transmitting antenna gain, dBi	10.0	Transmit peak gain, dB	43.1
		Angle toward LMDS receiver, degrees	180
Distance to subscriber, miles	3.9	Gain in direction of LMDS receiver, dB	-7.9
Free space loss, dB	-137.3		
		Distance to LMDS receiver, ft	385
Subscriber dish diameter, inches	15.0	Free space loss, dB	-102.8
Receiver antenna gain, dBi	38.4		
		LMDS receive antenna diameter, inches	15.0
Boltzman's constant, dBW/Hz•K	-228.6	LMDS receive peak gain, dB	38.4
Receiver noise temperature, dBK	29.5	Half power beamwidth, degrees	2.0
Bandwidth, dBHz	72.6	LMDS off-axis angle, degrees	180
		Relative angle (angle/beamwidth)	90.8
Carrier-to-noise ratio, dB	32.6	Relative antenna gain (App 30 Fig 8)	-43.2
		LMDS receiver gain, dB	-4.8
Rain attenuation (99.9% availability), dB	0.0		
		Rain attenuation (99.9% availability), dB	0.0
Rain faded carrier power, dBW	-94.0		
Noise power, dBW	-126.5	Interference power, dBW	-119.0
Rain faded carrier-to-noise ratio, dB	32.6	LMDS carrier power, dBW	-94.0
		Interference power, dBW	-119.0
		C/I, dB	25.0
		Required C/I, dB	25.0

Table 6 - SPACEWAY VSAT Interference into LMDS Receivers

1/11/94

Frequency, GHz	28.0	Rain rate for 0.01%, mm/hr	52.4
Lambda, m	0.011	Rain model constants: alpha	0.162
		beta	1.037

LMDS Carrier		SPACEWAY Interference	
Output power per channel, dBW/channel	-4.0	Output power per channel, dBW/channel	-3.5
Channel Bandwidth, MHz	18.0	Channel Bandwidth, MHz	0.5
Transmitting antenna feed loss, dB	1.0	Transmit antenna diameter, m	0.66
Transmitting antenna gain, dBi	10.0	Transmit peak gain, dB	43.1
		Angle toward LMDS receiver, degrees	180
Distance to subscriber, miles	3.9	Gain in direction of LMDS receiver, dB	-7.9
Free space loss, dB	-137.3		
		Distance to LMDS receiver, ft	2425
Subscriber dish diameter, inches	15.0	Free space loss, dB	-118.8
Receiver antenna gain, dBi	38.4		
		LMDS receive antenna diameter, inches	15.0
Boltzman's constant, dBW/Hz•K	-228.6	LMDS receive peak gain, dB	38.4
Receiver noise temperature, dBK	29.5	Half power beamwidth, degrees	2.0
Bandwidth, dBHz	72.6	LMDS off-axis angle, degrees	180
		Relative angle (angle/beamwidth)	90.8
Carrier-to-noise ratio, dB	32.6	Relative antenna gain (App 30 Fig 8)	-43.2
		LMDS receiver gain, dB	-4.8
Rain attenuation (99.9% availability), dB	18.7		
		Rain attenuation (99.9% availability), dB	2.7
Rain faded carrier power, dBW	-112.7		
Noise power, dBW	-126.5	Interference power, dBW	-137.7
Rain faded carrier-to-noise ratio, dB	13.8	LMDS carrier power, dBW	-112.7
		Interference power, dBW	-137.7
		C/I, dB	25.0
		Required C/I, dB	25.0

Figure 1 - Minimum Separation Between SPACEWAY VSAT and LMDS Receiver 1/11/94

Clear Sky, 4.5 in dish, 2.4 mi radius

Spaceway Antenna: RR App 29 Annex III

LMDS Antenna: RR App 30 Fig 8

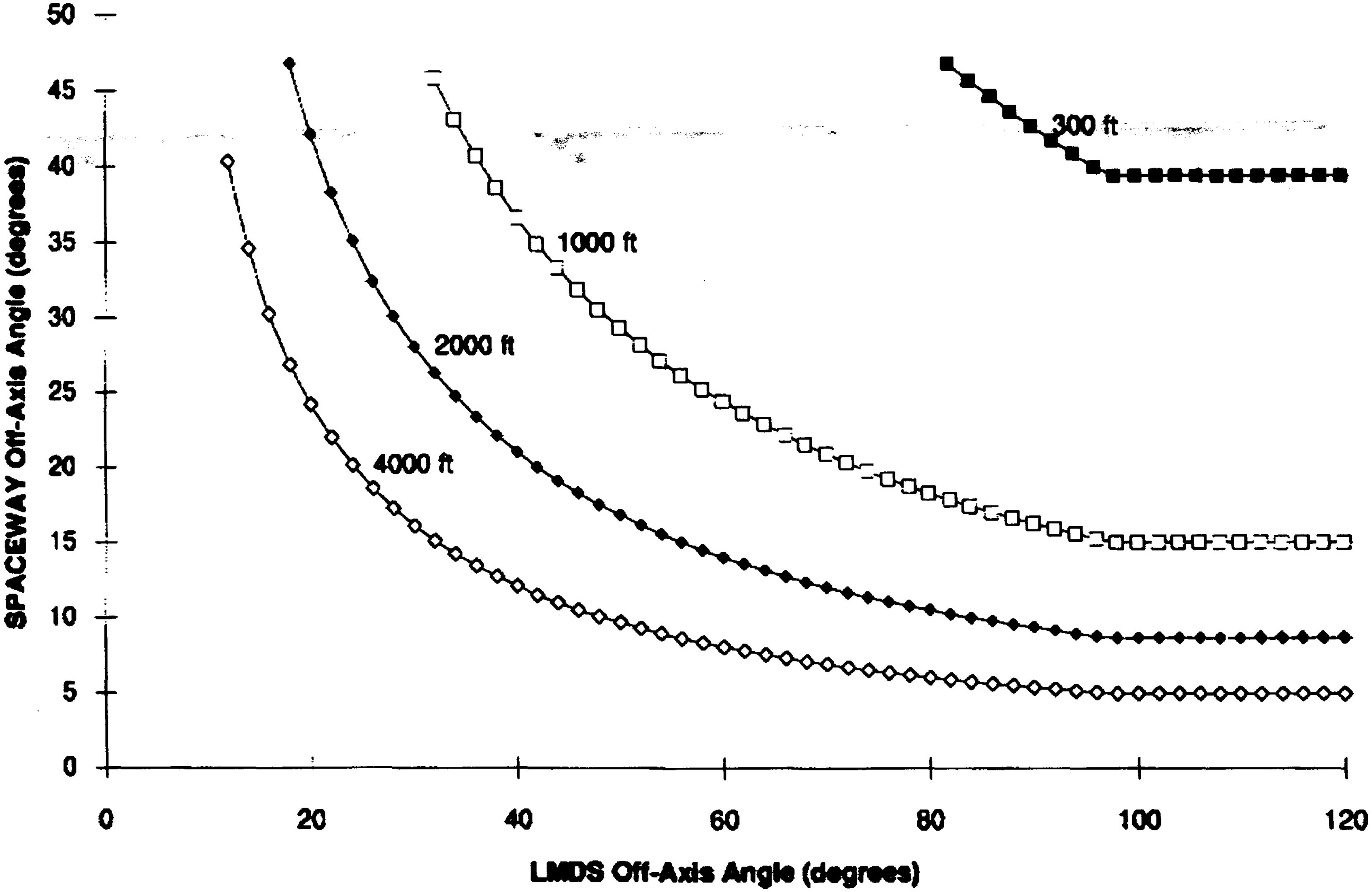

Figure 2 - Minimum Separation Between SPACEWAY VSAT and LMDS Receiver 1/11/94
New York, 4.5 in dish, 2.4 mi radius
Spaceway Antenna: RR App 29 Annex III
LMDS Antenna: RR App 30 Fig 8

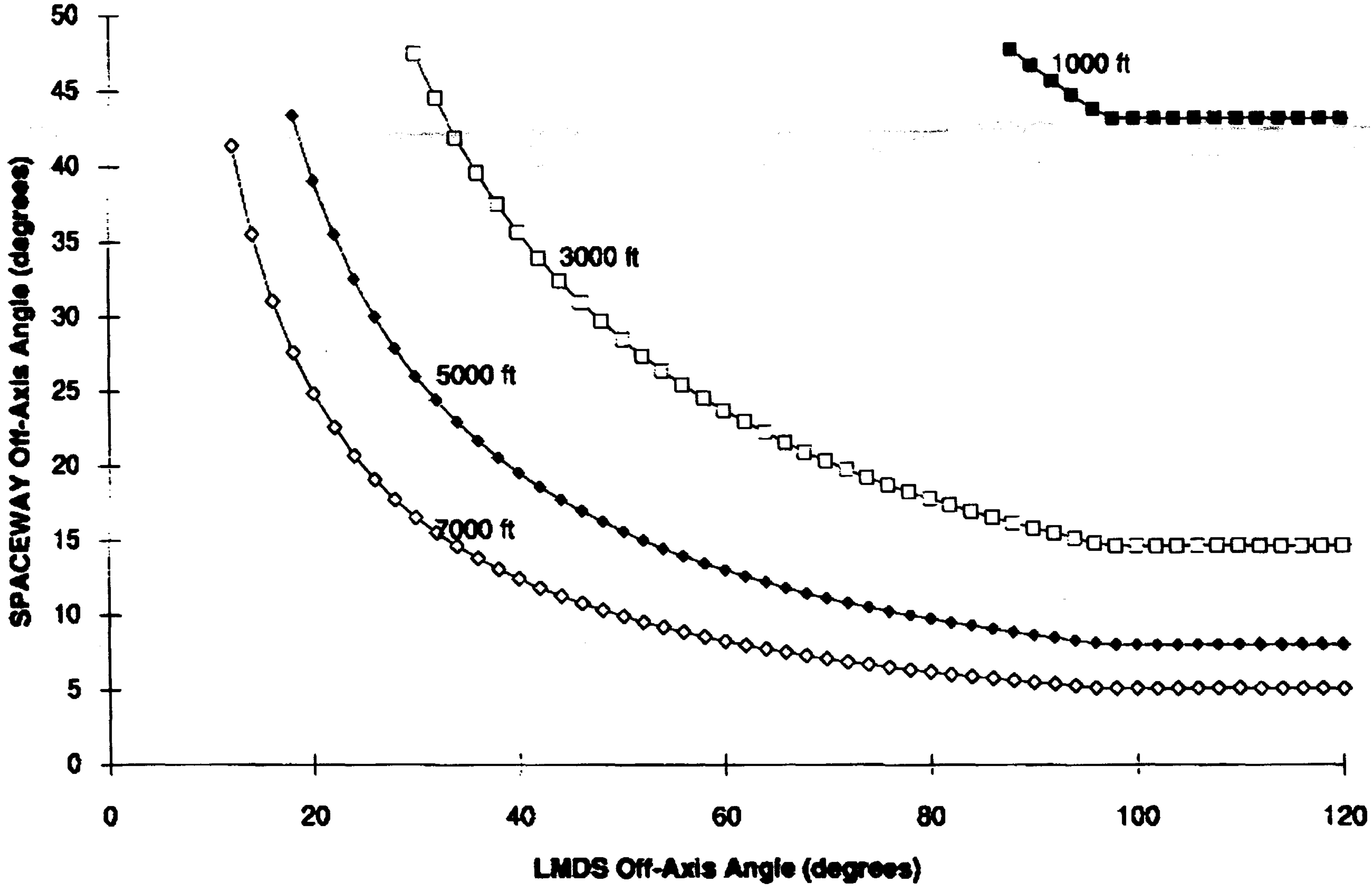

Figure 3 - Minimum Separation Between SPACEWAY VSAT and LMDS Receiver 1/11/94
New York, 7.5 in dish, 3.0 mi radius
Spaceway Antenna: RR App 29 Annex III
LMDS Antenna: RR App 30 Fig 8

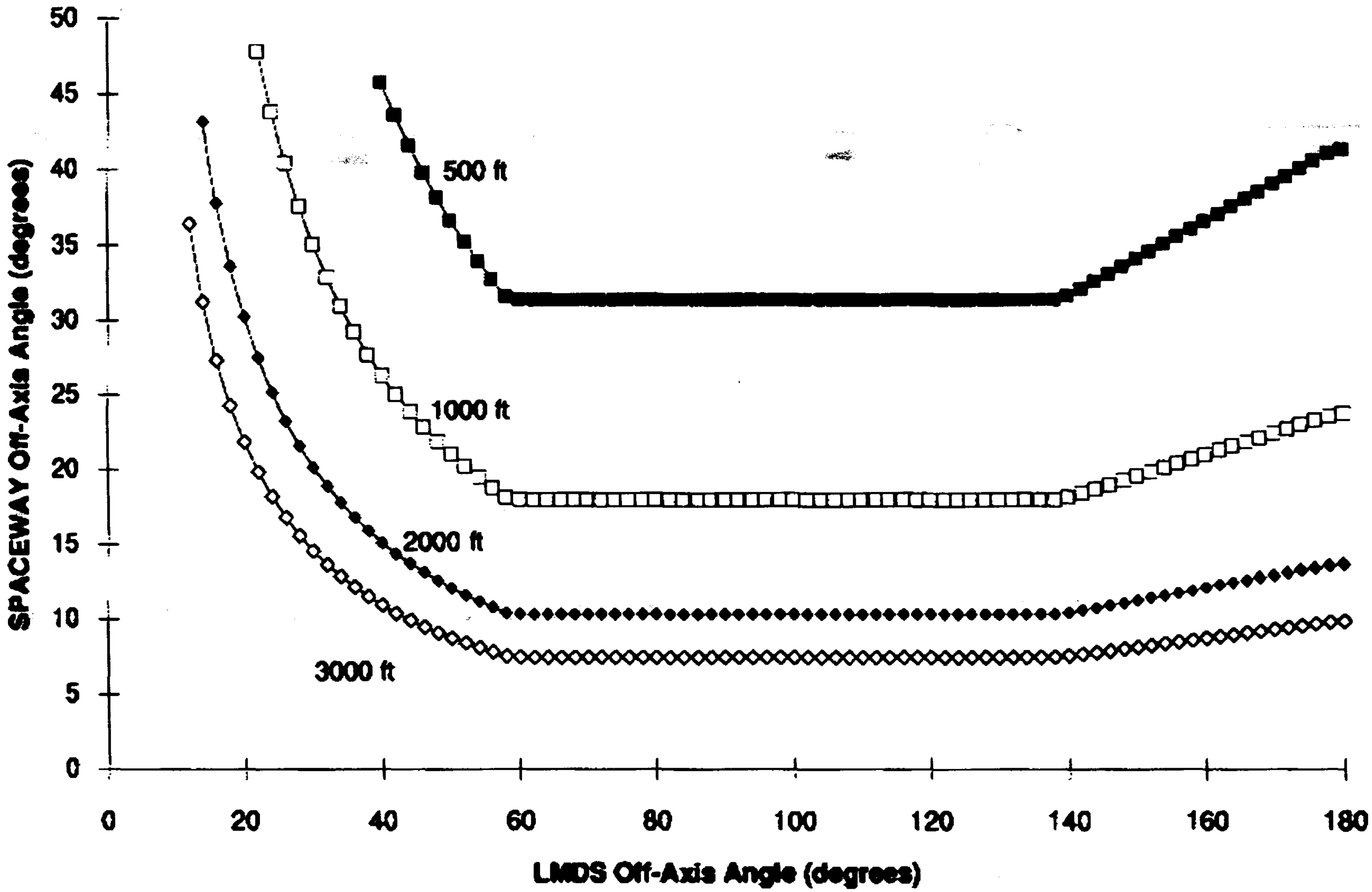

Figure 4 -Minimum Separation Between SPACEWAY VSAT and LMDS Receiver
New York, 7.5 in dish, 3.0 mi radius
Spaceway Antenna: RR App 29 Annex III
LMDS Antenna: RR App 30 Fig 8

1/11/94

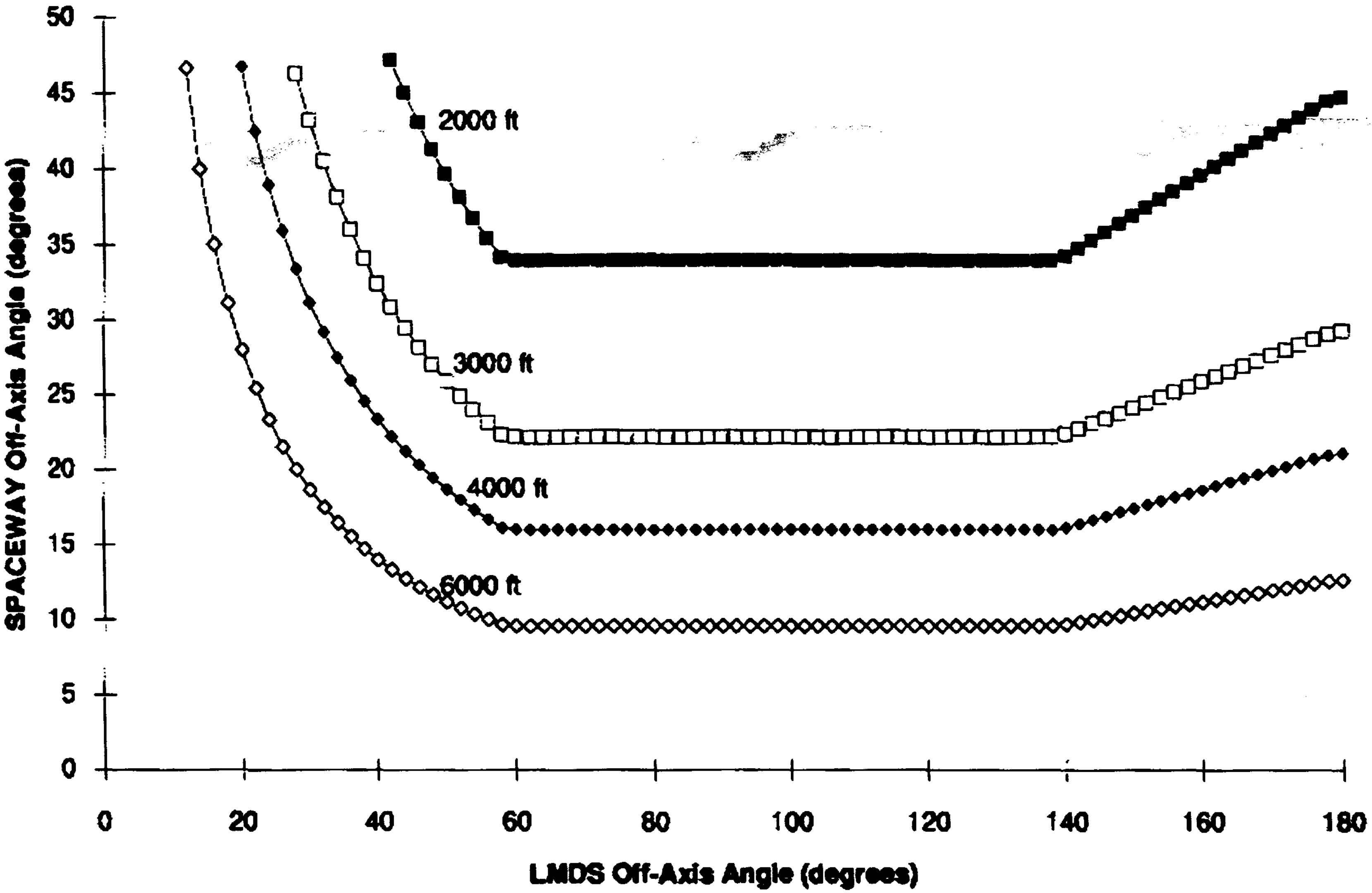

Figure 5 - Minimum Separation Between SPACEWAY VSAT and LMDS Receiver 1/11/94
Clear Sky, 15 in dish, 3.9 mi radius
Spaceway Antenna: RR App 29 Annex III
LMDS Antenna: RR App 30 Fig 8

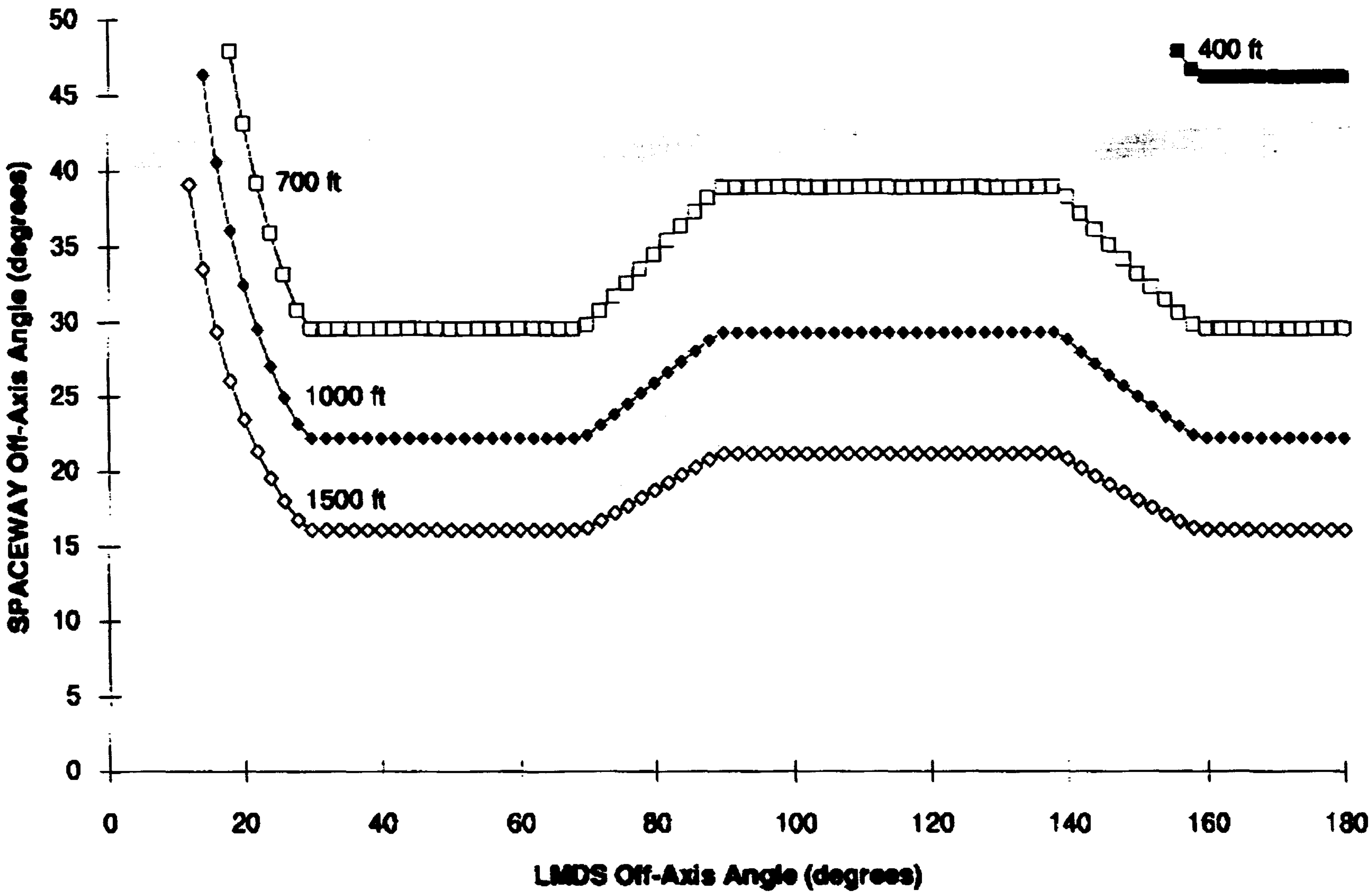

Figure 6 - Minimum Separation Between SPACEWAY VSAT and LMDS Receiver 1/11/94

New York, 15 in dish, 3.9 mi radius

Spaceway Antenna: RR App 29 Annex III

LMDS Antenna: RR App 30 Fig 8